WHAT IS CLAIMED IS:

1. A method of forming a nitride barrier layer, comprising the steps of:

exposing a dielectric layer to a silicon-containing species under low partial pressure to deposit a layer of silicon thereon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

2. The method of Claim 1, wherein the dielectric layer is exposed to the silicon-containing species at a partial pressure of about 10^{-2} Torr or less.

3. The method of Claim 1, wherein the dielectric layer is exposed to the silicon-containing species at pressure of about 10^{-2} to about 10^{-7} Torr.

4. The method of Claim 2, wherein the dielectric layer is exposed to the silicon-containing species at a temperature of about 500°C to about 700°C.

5. A method of forming a nitride barrier layer, comprising the steps of:

irradiating a dielectric layer with a silicon-containing species under low partial pressure to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

6. The method of Claim 5, wherein the silicon layer has a thickness of about 10 to about 30 angstroms.

7. A method of forming a nitride barrier layer, comprising the steps of:

exposing a dielectric layer to a silicon-containing species under low partial pressure to deposit a layer of about 10 to about 30 angstroms silicon thereon; and

nitridizing the silicon layer in a nitrogen-containing species to form a silicon nitride barrier layer.

8. A method of forming a nitride barrier layer, comprising the steps of:

exposing a surface of a dielectric layer to a silicon-containing species at a low partial pressure to nucleate the surface of the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

9. A method of forming a nitride barrier layer, comprising the steps of:

exposing a dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less to deposit a layer of about 10 to about 30 angstroms silicon thereon; and

nitridizing the silicon layer to form a silicon nitride barrier layer.

10. The method of Claim 9, wherein the dielectric layer is exposed to the silicon-containing species at a temperature of about 500°C to about 700°C.

11. The method of Claim 9, wherein the silicon-containing species is selected from the group consisting of dichlorosilane, silicon tetrachloride, silane, and disilane.

12. The method of Claim 9, wherein the step of exposing the dielectric layer to the silicon-containing species is by plasma enhanced chemical vapor deposition, low pressure chemical vapor deposition, or rapid thermal chemical vapor deposition.

13. The method of Claim 9, wherein the silicon-containing species is deposited by rapid thermal chemical vapor deposition at about 500°C. to about 700°C.

14. The method of Claim 9, wherein the dielectric layer comprises silicon dioxide.

15. The method of Claim 9, wherein the dielectric layer comprises a dielectric material selected from the group consisting of tantalum pentoxide, hafnium dioxide, and aluminum trioxide.

16. A method of forming a nitride barrier layer, comprising the steps of:

exposing a dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} to about 10^{-7} to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

17. A method of forming a nitride barrier layer, comprising the steps of:

exposing a dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} to about 10^{-7}, a temperature of about 500°C. to about 700°C., and a duration of about 1 second to about 5 minutes, to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

18. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

thermally annealing the silicon layer in a nitrogen-containing species.

19. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a nitrogen-containing species at a temperature of about 700°C. to about 900°C. to nitridize the silicon layer.

20. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a nitrogen-containing species at a temperature of about 700°C. to about 900°C., a pressure of about 1 to about 760 Torr, and a flow rate of about 100 to about 10,000 sccm, for about 1 second to about 180 minutes to nitridize the silicon layer.

21. The method of Claim 20, wherein the nitrogen-containing species is selected from the group consisting of nitrogen, ammonia, nitrogen trifluoride, nitrogen oxide, and a nitrogen-helium mixture.

22. The method of Claim 21, wherein the silicon layer is exposed to a plasma source of nitrogen.

23. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a plasma source of a nitrogen-containing species to nitridize the silicon layer.

24. The method of Claim 23, wherein the plasma source of the nitrogen-containing species is produced by a downstream microwave system, an electron cyclotron residence system, an inductive coupled plasma system, or a radio frequency system.

25. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a remote microwave plasma source of a nitrogen-containing species at a pressure of about 1 to about 20 Torr to nitridize the silicon layer.

26. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a remote microwave plasma source of a nitrogen-containing species at a pressure of about 1 to about 20 Torr, and a temperature of about 700°C. to about 900°C. to nitridize the silicon layer.

27. A method of forming a nitride barrier layer, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to an inductive coupled plasma source of a nitrogen-containing species at a pressure of about 1 to about 20 Torr to nitridize the silicon layer.

28. A method of forming a semiconductor device, comprising the steps of:

irradiating a dielectric layer disposed on a silicon substrate with a silicon-containing species under low partial pressure to nucleate the dielectric layer with a layer of silicon; and

nitridizing the silicon layer.

29. The method of Claim 28, wherein the step of irradiating the dielectric layer with the silicon-containing species is at a partial pressure about 10^{-2} Torr or less.

30. The method of Claim 29, wherein the step of irradiating the dielectric layer is at a partial pressure of about 10^{-2} to about 10^{-7} Torr.

31. The method of Claim 29, wherein the silicon-containing species is selected from the group consisting of dichlorosilane, silicon tetrachloride, silane, and disilane.

32. The method of Claim 28, wherein the step of irradiating the dielectric layer with the silicon-containing species is by plasma enhanced chemical vapor deposition, low pressure chemical vapor deposition, or rapid thermal chemical vapor deposition.

33. The method of Claim 28, wherein the step of irradiating the dielectric layer with the silicon-containing species is by rapid thermal chemical vapor deposition at a temperature of about 500°C to about 700°C.

34. The method of Claim 28, wherein the dielectric layer comprises silicon dioxide.

35. The method of Claim 28, wherein the dielectric layer comprises a dielectric material selected from the group consisting of tantalum pentoxide, hafnium dioxide, and aluminum trioxide.

36. A method of forming a semiconductor device, comprising the steps of:

exposing a dielectric layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less to nucleate the dielectric layer with a layer of silicon; and

nitridizing the silicon layer in a nitrogen-containing species.

37. A method of forming a semiconductor device, comprising the steps of:

exposing an oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less to nucleate the dielectric layer with a layer of silicon; and

thermally annealing the silicon layer in a nitrogen-containing gas.

38. A method of forming a semiconductor device, comprising the steps of:

exposing an oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species at a temperature of about 700°C. to about 900°C. to nitridize the silicon layer.

39. A method of forming a semiconductor device, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low partial pressure to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a plasma source of a nitrogen-containing species to nitridize the silicon layer.

40. The method of Claim 39, wherein the plasma source of the nitrogen-containing species is produced by a downstream microwave system, an electron cyclotron residence system, an inductive coupled plasma system, or a radio frequency system.

41. A method of forming a semiconductor device, comprising the steps of:

depositing a silicon layer onto a dielectric layer by exposing the dielectric layer to a silicon-containing species under low a partial pressure of about 10^{-2} Torr or less to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a remote microwave plasma source of a nitrogen-containing species at a pressure of about 1 to about 20 Torr to nitridize the silicon layer.

42. A method of forming a gate electrode, comprising the steps of:

exposing a gate oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less to nucleate the dielectric layer with a layer silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

43. A method of forming a gate electrode, comprising the steps of:

exposing a gate oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} to about 10^{-7} to nucleate the dielectric layer with a layer of silicon; and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

44. A method of forming a gate electrode, comprising the steps of:

exposing a gate oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} to about 10^{-7}, a temperature of about 500°C. to about 700°C., and a duration of about 1 second to about 5 minutes, to nucleate the dielectric layer with a layer of silicon and

exposing the silicon layer to a nitrogen-containing species to form a silicon nitride barrier layer.

45. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the gate oxide layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less; and

thermally annealing the silicon layer in a nitrogen-containing species.

46. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the gate oxide layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less; and

exposing the silicon layer to a nitrogen-containing species at a temperature of about 700°C. to about 900°C. to nitridize the silicon layer to a silicon nitride layer.

47. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the dielectric layer to a silicon-containing species under low partial pressure; and

exposing the silicon layer to a nitrogen-containing species at a temperature of about 700°C. to about 900°C., a pressure of about 1 to about 760 Torr, a flow rate of about 100 to about 10,000 sccm, for about 1 second to about 180 minutes to nitridize the silicon layer.

48. The method of Claim 47, wherein the nitrogen-containing species is selected from the group consisting of nitrogen, ammonia, nitrogen trifluoride, nitrogen oxide, and a mixture of nitrogen and helium.

49. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less; and

exposing the silicon layer to a plasma source of a nitrogen-containing species to nitridize the silicon layer.

50. The method of Claim 49, wherein the plasma source of the nitrogen-containing species is produced by a downstream microwave system, an electron cyclotron residence system, an inductive coupled plasma system, or a radio frequency system.

51. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less; and

exposing the silicon layer to a remote microwave plasma source of a nitrogen-containing species at a temperature of about 700°C. to about 900°C., and a pressure of about 1 to about 20 Torr to nitridize the silicon layer.

52. A method of forming a gate electrode, comprising the steps of:

depositing a silicon layer onto a gate oxide layer disposed on a silicon substrate by exposing the dielectric layer to a silicon-containing species at a partial pressure of about 10^{-2} Torr or less; and

exposing the silicon layer to an inductive coupled plasma source of a nitrogen-containing species at a pressure of about 1 to about 20 Torr to nitridize the silicon layer.

53. A method of forming a gate electrode, comprising the steps of:

exposing a gate oxide layer disposed on a silicon substrate to a silicon-containing species at a partial pressure of about 10^{-2} to about 10^{-7} to nucleate the dielectric layer with a layer of silicon;

nitridizing the silicon layer in a nitrogen-containing species to form a silicon nitride barrier layer; and

forming a conductive polysilicon layer comprising a conductivity enhancing dopant over the nitride barrier layer; wherein the nitride barrier layer inhibits passage of the dopant from the conductive polysilicon layer therethrough.

54. The method of Claim 53, wherein the polysilicon layer comprises a boron dopant.

55. The method of Claim 53, further comprising:
forming an insulative nitride cap over the conductive polysilicon layer; and
patterning the layers to form a gate stack.

56. The method of Claim 53, further comprising:
forming a barrier layer over the doped polysilicon layer;
forming a conductive metal layer over the barrier layer;
forming an insulative nitride cap over the conductive metal layer; and
patterning the layers to form a gate stack.

57. The method of Claim 53, further comprising:
forming a metal silicide layer over the doped polysilicon layer;
forming an insulative nitride cap over the metal silicide layer; and
patterning the layers to form a gate stack.

58. A nitride barrier layer, comprising:

a nitridized silicon layer of less than about 30 angstroms disposed on an oxide layer, and formed by irradiation of the oxide layer with a silicon-containing species under low partial pressure in the presence of a nitrogen-containing species.

59. A nitride barrier layer, comprising: a nitridized silicon layer having a thickness of less than about 30 angstroms, and disposed adjacent an oxide layer.

60. A nitride barrier layer, comprising: an annealed nitridized silicon layer having a thickness of less than about 30 angstroms, and disposed adjacent an oxide layer.

61. The barrier layer of Claim 60, wherein the barrier layer is thermally annealed.

62. The barrier layer of Claim 60, wherein the barrier layer is plasma annealed.

63. A semiconductor device comprising:

a semiconductor substrate comprising silicon;

an oxide layer disposed adjacent to the semiconductor substrate; and

a diffusion barrier layer disposed adjacent the oxide layer; the diffusion barrier layer having a thickness of less than about 30 angstroms, and comprising a nitridized silicon layer formed by irradiation of an oxide layer with a silicon-containing species under low partial pressure in the presence of a nitrogen-containing species,

64. A semiconductor device comprising:

a semiconductor substrate comprising silicon;

an oxide layer disposed adjacent to the semiconductor substrate; and

a diffusion barrier layer disposed adjacent the oxide layer, and comprising nitridized silicon having a thickness of about 10 to about 20 angstroms.

65. A semiconductor device comprising:

a semiconductor substrate comprising silicon;

an oxide layer disposed adjacent to the semiconductor substrate; and

a diffusion barrier layer disposed adjacent the oxide layer, and comprising nitrogen annealed silicon and having a thickness of about 10 to about 20 angstroms.

66. The device of Claim 65, wherein the diffusion barrier layer comprises plasma annealed silicon.

67. The device of Claim 65, wherein the diffusion barrier layer comprises thermally annealed silicon.

68. A gate electrode, comprising:

a gate oxide layer disposed adjacent to a semiconductor substrate; and

a diffusion barrier layer disposed adjacent the gate oxide layer; the diffusion barrier layer having a thickness of about 10 to about 20 angstroms and comprising a nitridized silicon layer deposited by irradiating an oxide layer with a silicon-containing species under low partial pressure, and nitridizing the silicon layer by exposure to a nitrogen-containing species.

69. A gate electrode, comprising:

a gate oxide layer disposed adjacent to a semiconductor substrate; and

a diffusion barrier layer disposed adjacent the oxide layer, and comprising a nitridized silicon layer having a thickness of about 10 to about 20 angstroms.

70. A gate electrode, comprising:

a gate oxide layer disposed adjacent to a semiconductor substrate; and

a diffusion barrier layer disposed adjacent the oxide layer, and comprising nitrogen annealed silicon and having a thickness of about 10 to about 20 angstroms.

71. The electrode of Claim 70, wherein the diffusion barrier layer comprises plasma annealed silicon.

72. The electrode of Claim 70, wherein the diffusion barrier layer comprises thermally annealed silicon.

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